

National Aeronautics and Space Administration



# The Integrated Space Weather Analysis System

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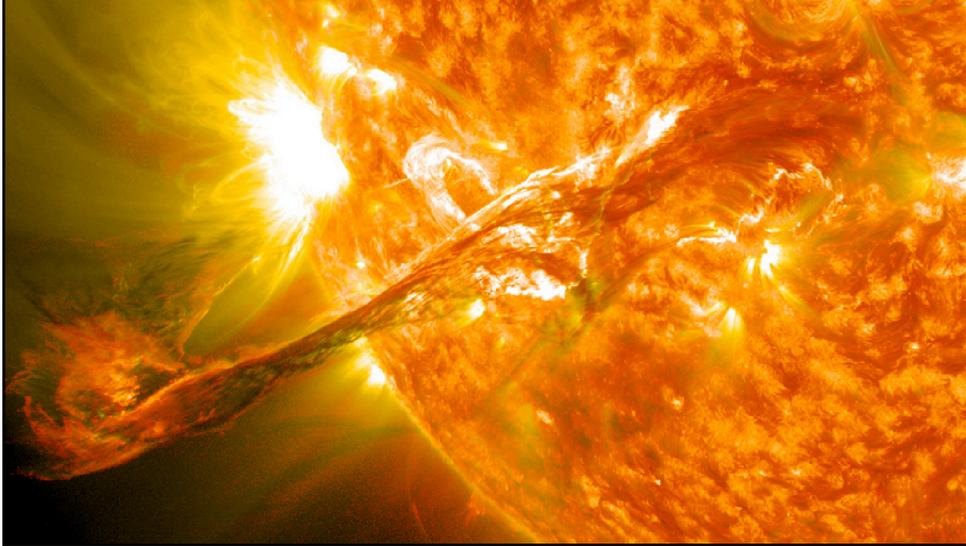
*Space Weather Training*  
*Kennedy Space Center*

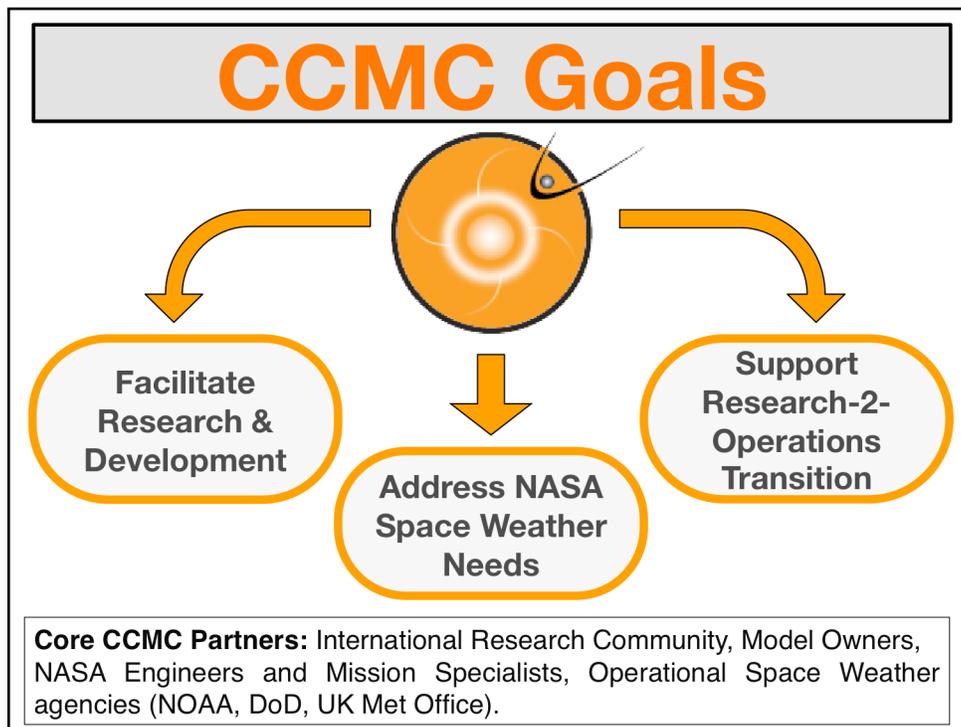
<http://ccmc.gsfc.nasa.gov>



www.nasa.gov

**How Do You Quickly Determine Past, Present, & Expected Space Weather Impacts?**





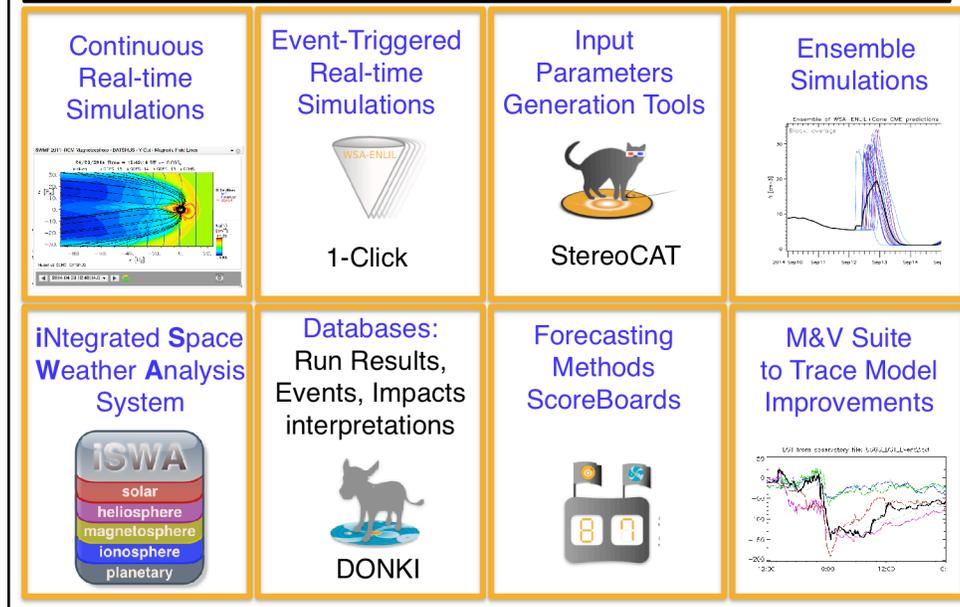
The CCMC Now is pursuing the following goals:

facilitate research, education and development of next generation Space weather models and tools.

Support research models and advanced forecasting techniques transition to operations.

Address unique space weather needs of NASA user.

## CCMC Tools, Systems, & Databases for Research, Analysis, Metrics & Validation, Forecasting



Examples of Tools, Systems & Databases for Research Analysis, M&V, Forecasting  
(AVAILABLE ONLINE, ACCESSIBLE WORLD-WIDE)

### CONTINUOUS REAL-TIME SIMULATIONS

Models continuously running in real-time (with real-time drivers).

Data flow monitoring and controlling systems

### EVENT-TRIGGERED REAL-TIME SIMULATIONS

1-Click system to submit event-triggered forecasting simulations (e.g., Enlil Cone Model).

Enables any interested person to generate forecasts.

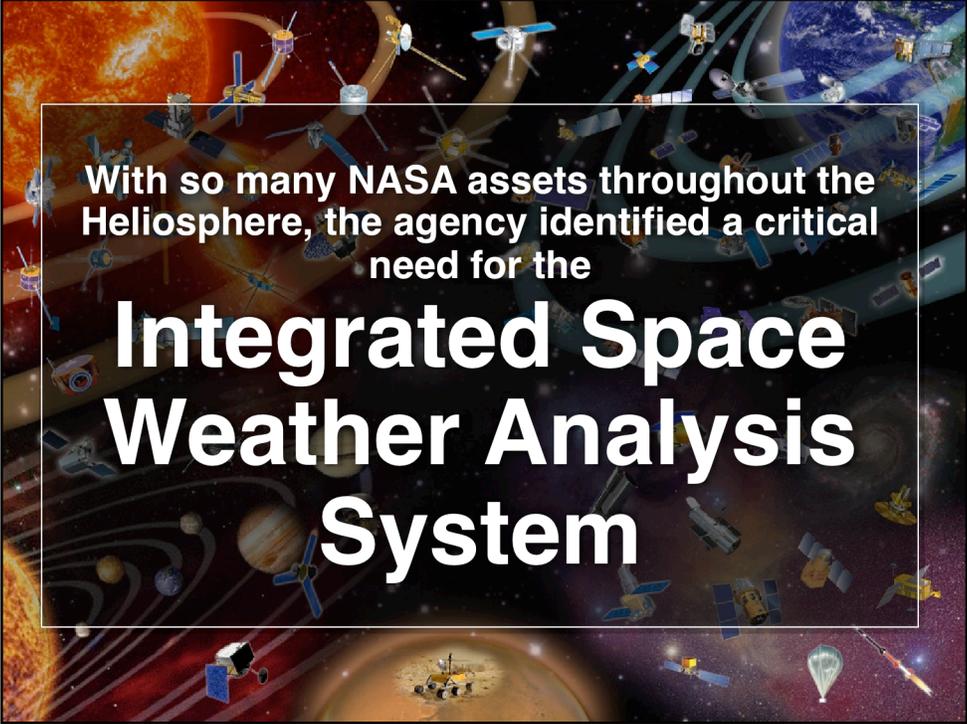
### INPUT PARAMETERS GENERATION TOOLS

*Stereo Coronal Mass Ejection Analysis Tool (StereoCAT)* is a component of the CCMC's on-line Input Parameters Generation Suite that enables RoR users and space weather forecasters to quickly calculate the kinematic properties of Coronal Mass Ejections (CMEs). With a few mouse clicks, StereoCAT uses triangulation of SOHO and STEREO coronagraph images to determine CME speed, direction, and opening angle. The derived CME parameters can be utilized as input for a broad range of CME propagation models (including real-time Enlil-Cone model of CME propagation).

### ENSEMBLE SIMULATIONS

to address uncertainties in input parameters

### M&V SUITE TO TRACE MODEL IMPROVEMENTS



With so many NASA assets throughout the Heliosphere, the agency identified a critical need for the

# Integrated Space Weather Analysis System



## iSWA Solution & Deliverables



1. Acquire, ingest, and produce NASA relevant space weather information
2. Utilize both observational and simulation/model data
3. Produce and provide real-time data streams
4. Categorize and archive data for historical impact analysis
5. Provide customizable and highly configurable displays
6. Disseminate through the most widely deployed and accessible interface – the web

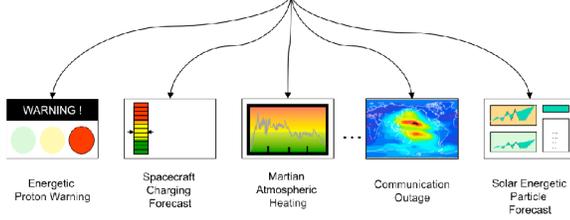
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Observational data tells you what is happening now.

Model & Simulation data provides forecasts of expected/predicted space weather activity.

Customization allows users to select regions and phenomenon of interest.

# INTEGRATED SPACE WEATHER ANALYSIS SYSTEM



Highly diverse and distributed space weather data consisting of the latest observational data along with the most advanced space weather model simulation output.

iSWA system collects data from a large and evolving list of sources. Data is sorted, characterized, and processed into 'mission decision supporting' products in response to individual user queries.

iSWA generates and provides a user-configurable display panel that can be accessed from a standard web browser. The end user can then customize their display to focus on specific products of interest.

# INTEGRATED SPACE WEATHER ANALYSIS SYSTEM



## Data Management Challenges



- Ingesting data streams from a variety of sources with varying:
  - Transfer Methods ( push and pull )
  - Levels of availability
  - Access Protocols ( http, ftp, scp, mv )
  - Naming Conventions
  - Update Intervals ( efficient polling for new data )
  - Date & Time Stamp Formats i.e.  
[ 2011-01-01\_212500 ] or [ 2011-1-1\_212500 ] or [ 20100101\_212500 ] or  
[ 2011\_001\_212500 ] or [ 2010\_Jan\_01\_212500 ] or [ latest ] or...
- Sorting, Archiving, and Management
  - Persistent storage ( file system or database )
  - Cataloging, How to keep track of what is where
  - Scalability, Additional storage
- Changes ( urls, names, formats, extensions, etc. )



# Innovative Dissemination



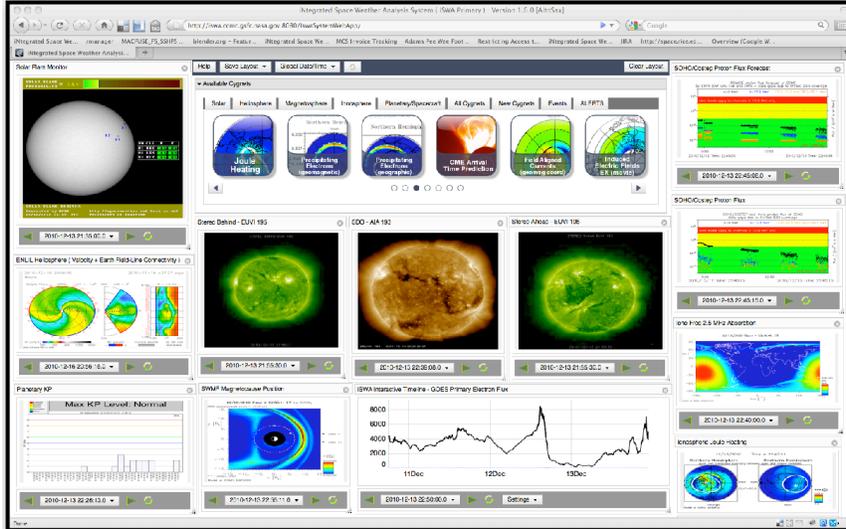
ISWA has ~300 products including modeling results and comprehensive sets of observational data.



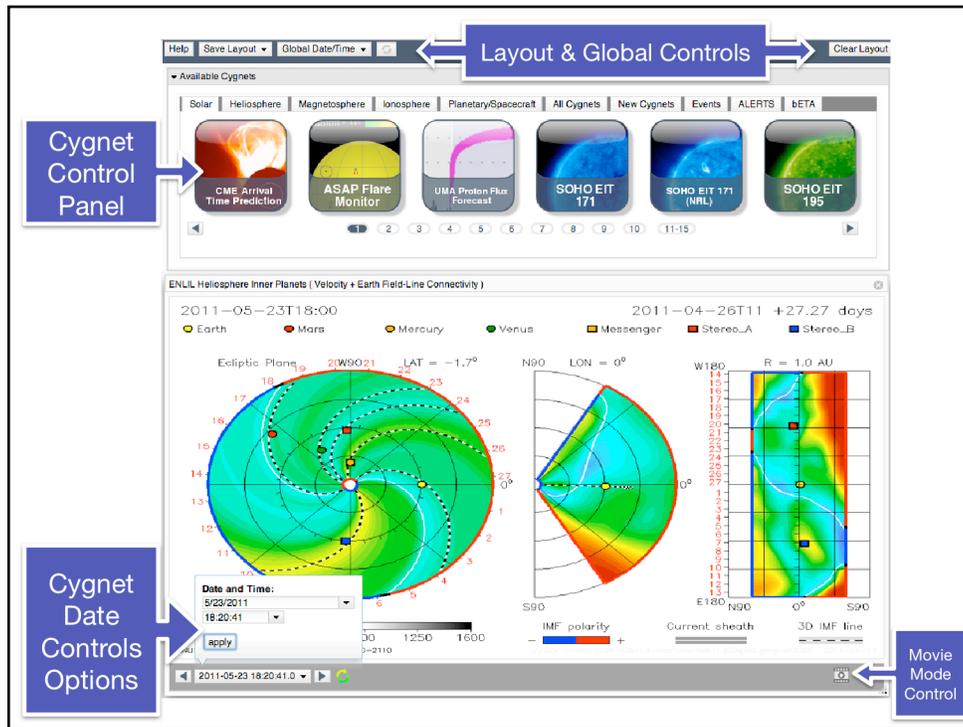
**Web-based. User configurable. Available world-wide.**  
**One-stop shop for state-of-the-art information!**  
<http://iswa.gsfc.nasa.gov>



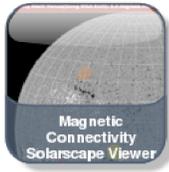
# Unprecedented Access to Space Weather Information



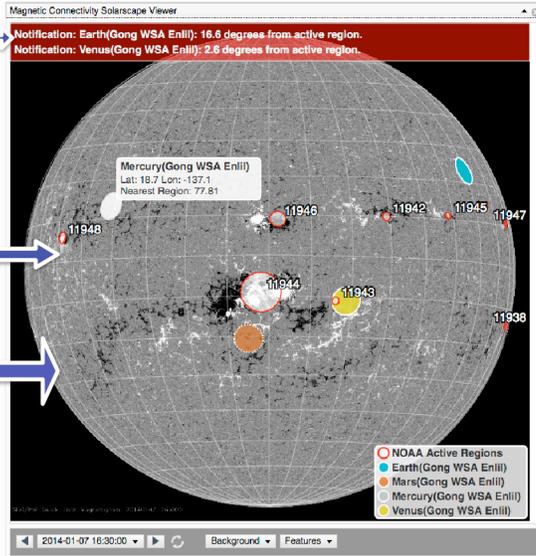
<http://iswa.ccmc.gsfc.nasa.gov>



## Dynamically Generated & Interactive Products: Solarscape



Alerts/  
Notifications

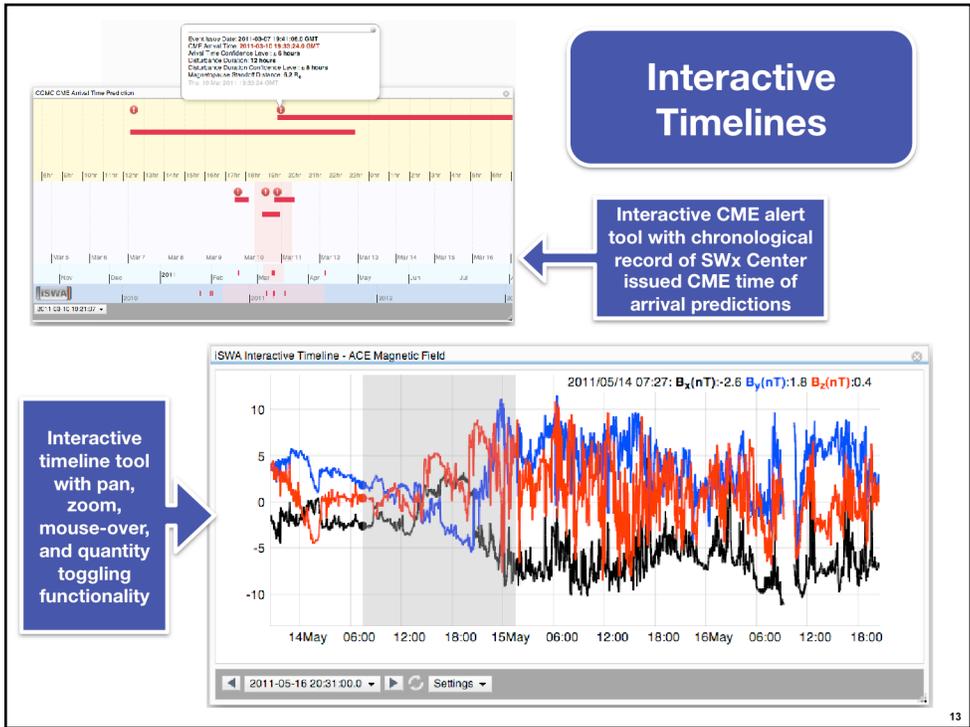


User Selectable Features  
( MAG4, NOAA Active Regions,  
CCMC Magnetic Connectivity )

User Selectable Background  
( SDO , Generic Grid )

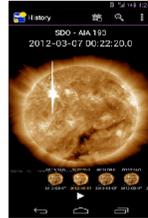
Dynamic Product with User Selectable Features From Several Sources





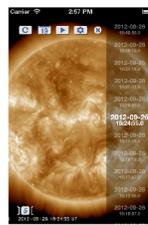


# Mobile Access Powered by iSWA



## Android Front-End to iSWA

- History Mode
- Movie Mode
- >50k Downloads
- Available in Google Play Store



## iOS Front-End to iSWA

- >100k Downloads
- Available in App Store



## Services for NASA Robotic Missions Powered by iSWA



1. Providing assistance in spacecraft anomaly resolution by assessing whether space weather has any role in causing the observed anomaly/ anomalies.
2. Sending out weekly space weather reports/ summaries to NASA mission operators, NASA officials and involved personnel.





# Education And Training Powered by iSWA



Arranged by NASA IV&V Educator Resource Center  
High school teachers from West Virginia

Y. Zheng



# Undergraduate Computer Science Interns SW Research Analysis Tool Development Powered by iSWA



## Jack LaSota

Web-based CME Analysis Tool

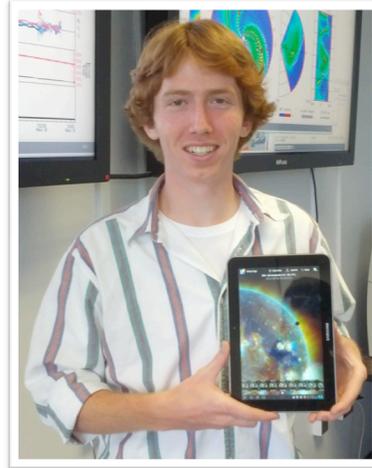


[CME Tool Link](#)

[Sample Analysis Link](#)

## Justin Boblitt

Android iSWA App



[iTunes Link](#)

[Android Link](#)



# iSWA Impact



## **NASA**

- iSWA provides a new capability to quickly assess [past](#), [present](#), and [expected](#) space weather effects.
  - Mission operators have a resource to assist in both anomaly resolution as well as potential space weather impacts.
- iSWA has helped enable the Space Weather Laboratory to establish a new **Space Weather Center** service [providing alerts](#), anomaly reports, and weekly space weather summaries based on iSWA tools and products.

## **External Agencies**

- Air Force Space Weather Agency can [monitor the iSWA system 24x7 for CME eruptions](#) and notify the CCMC as soon as an event is detected. A notification triggers a CME Cone Model calculation at CCMC that [estimates the CME arrival time, duration, and expected impact on earth](#).
- iSWA has enabled numerous collaborations with data, model, and product developers/providers who want their tools to be available in iSWA.

## **Science, Education, and Public Outreach**

- Researchers, universities, and “citizen scientists” have access to a comprehensive suite of real-time and historical space environment data products.

# Who Uses iSWA?

The following logos are displayed in the image:

- NASA
- NOAA
- NSF
- Department of Defense
- Department of Science and Technology
- Department of the Navy
- ONR (Office of Naval Research)
- NASA Johnson Space Center
- ESA (European Space Agency)
- EMBRY-RIDDLE Aeronautical University
- CSEM (Center for Space and Earth Modeling)
- NCAR (National Center for Atmospheric Research)
- ASTRA
- KASI (Korea Aerospace Research Institute)
- Predictive Science, Inc.
- EPRI (Electric Power Research Institute)
- SPENVIS (Space Environment Information System)
- UNIVERSITY of NEW HAMPSHIRE
- KMA (Korea Meteorological Administration)
- THE CATHOLIC UNIVERSITY of AMERICA
- CASS (China Academy of Space and Astronautics)
- IAGA (International Association of Geomagnetism and Aeronomy)
- CISM (Canadian Space Institute)
- Met Office
- ICARUS RESEARCH, INC.
- JAXA (Japan Aerospace Exploration Agency)
- FINNISH METEOROLOGICAL INSTITUTE
- NiCT (National Institute of Space and Astronautical Science)
- Dartmouth College
- APL (Applied Physics Laboratory)
- STEL (Space and Terrestrial Environment Laboratory)
- BOSTON UNIVERSITY



## Potential Users



- Any agency, entity, or individual with space weather requirements and/or interests
- Extended educational use ( training, K-12, higher education )
- Extended research use ( case studies, correlation studies, historical events, general space weather research )

**iSWA software can be applied to any agency, group, or project with general data ingestion, storage, management, display, & dissemination needs....**

- “instant ground system” for other NASA projects
- turn-key software system for commercial and/or educational data management and dissemination
- customizable interface for existing data archives and sets

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Potential use...

Integrated Space Weather Analysis System (ISWA Primary) - Version 1.6.0 (beta)

http://iwa.cmc.gsfc.nasa.gov:3030/iwaSystemWebApp/

Star Field Monitor

Available Cycles

Star Field Monitor: A 3D visualization of the star field, showing a dense cluster of stars in the foreground and a sparser field in the background. The stars are color-coded by magnitude and distance.

Available Cycles: A set of icons representing different data cycles and parameters, including Joule Heating, Precipitating Ionosphere, Precipitating Ionosphere (topography), CME Arrival Time Forecast, Field Aligned Currents, and Ionospheric Structure. Each icon is accompanied by a small thumbnail image.

SOHO Coronal Photon Flux Forecast: A plot showing the forecast of the Coronal Photon Flux (CPFF) from SOHO. The y-axis represents the flux in units of photons/cm<sup>2</sup>/s, and the x-axis represents time. The plot shows a series of peaks and troughs, indicating the presence of coronal mass ejections (CMEs) and other solar activity.

ENLIL Heliosphere (Velocity) Earth Field Lines (connectivity): A visualization of the Earth's magnetic field lines and the heliosphere. The Earth is shown at the center, with field lines extending outwards. The heliosphere is shown as a large, irregularly shaped region surrounding the Earth.

Stereo Behr - EUVI 1B: A series of three panels showing the Earth as seen from the Stereo Behr spacecraft. The panels show the Earth's surface and the surrounding space environment, with a focus on the EUVI 1B instrument's field of view.

SDO - AI 113: A visualization of the Sun's surface, showing the AI 113 instrument's field of view. The Sun is shown as a bright, glowing sphere with various features and structures on its surface.

STEREO Ahead - EUVI 1B: A series of three panels showing the Earth as seen from the STEREO Ahead spacecraft. The panels show the Earth's surface and the surrounding space environment, with a focus on the EUVI 1B instrument's field of view.

SOHO F12.5 MHz AIA2007: A visualization of the Sun's surface, showing the SOHO F12.5 MHz AIA2007 instrument's field of view. The Sun is shown as a bright, glowing sphere with various features and structures on its surface.

Ionospheric Joule Heating: A visualization of the ionospheric Joule heating process. The Earth is shown at the center, with a color-coded map of the ionosphere showing the distribution of Joule heating. The map shows a high concentration of heating in the polar regions.

Metamery KP: A plot showing the Metamery KP index. The y-axis represents the KP index, and the x-axis represents time. The plot shows a series of peaks and troughs, indicating the presence of geomagnetic storms and other space weather events.

SWMF Macroturbulence Position: A visualization of the Macroturbulence Position (MTP) in the SWMF model. The plot shows the MTP as a function of time, with a color-coded map of the ionosphere showing the distribution of MTP.

iSWA Interactive Timeline - GLEES Primary Electron Flux: A plot showing the Primary Electron Flux (PEF) from the GLEES instrument. The y-axis represents the PEF in units of electrons/cm<sup>2</sup>/s, and the x-axis represents time. The plot shows a series of peaks and troughs, indicating the presence of CMEs and other space weather events.

http://iwa.cmc.gsfc.nasa.gov